1-1-1942

Influence of breakfast on muscular coordination, muscle strength and memory in certain Iowa State College women

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INFLUENCE OF BREAKFAST ON MUSCULAR COORDINATION, MUSCLE STRENGTH AND MEMORY IN CERTAIN IOWA STATE COLLEGE WOMEN

by

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A Thesis Submitted to the Graduate Faculty
for the Degree of

MASTER OF SCIENCE

Major Subject: Nutrition

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I. INTRODUCTION

The body requires a supply of energy from without for internal and external work, for growth and repair and for heating the body (Bogert, 1940). This energy is furnished by the food eaten. Carbohydrates, proteins and fats are the substances which the body can use for energy. Minerals, vitamins and water are useless for this purpose, yet they play an equally important role in nutrition as building stones for fundamental tissues. More recently, attention has been called to the way in which the body utilizes food. Many utilization problems are a function of the adequacy of digestion and absorption (Stearns, 1942). Hence we realize, today, that nutrition should be considered from the standpoint of the body as a whole in its relation to food, and not simply the supply of food.

It is generally recognized that habits of living have some influence on health, but these factors seldom are allotted the importance they deserve. In malnourished and underweight individuals, a number of poor food and health habits generally are found. Sometimes a single habit, unfavorable to health, will prevent the return to normal nutritive condition.

The literature on the spacing of meals as it affects human efficiency is entirely lacking and somewhat evasive. The distribution of the daily dietary into three meals has

been accepted without question in this country; however, four or five meals per day are characteristic of many older civilizations. During recent years the breakfast meal has been dropped from the dietary by many persons. Haggard (1935) states that muscular efficiency is lowest before breakfast, a time when people are rested and most free from fatigue in the ordinary sense. Muscular inefficiency is more or less unnoticed by the individual accustomed to no breakfast and as a result may be neglected, since awareness of a given physical state requires a basis for comparison with a more favorable condition.

The purpose of this study has been to examine the relative importance of breakfast in the daily dietary by means of its effect on the individual's muscle strength, muscle coordination and memory on days with and without breakfast.

II. REVIEW OF LITERATURE

The quality and quantity of food eaten has been taken into account in the study of nutrition, but the distribution of the diet in time - that is, the intervals at which the food is taken, has yet to receive the consideration it deserves.

A. Nutrition and Physical Efficiency

1. The place of breakfast in supplying the day's requirement of specific nutrients.

Breakfast (Haggard, 1935) in many homes, due to economic and/or social conditions, is the lightest meal of the day in spite of the fact that it follows the longest fast period. This meal, light as it frequently is, has its place in the daily dietary. When well-planned, breakfast makes a worth-while nutritive contribution to the day, since it provides an opportunity for the intake of whole grain cereals, fruits and wholesome beverages.

Haggard (1935) reports the chief reasons for omission of breakfast are as follows:

1. Disinclination for food
2. Overweight (women)
3. Financial condition

The committee on Food and Nutrition of the National Research Council (May 1941) recommends the following daily allowances of specific nutrients for girls 16 to 20 years:

Table I

Recommended Daily Allowance for Specific Nutrients: Girls 16 to 20 Years

Calories	Protein	Calcium	Iron	A	Thiamin	Ascorbic Acid	Riboflavin	Nicotinic Acid	Vitamin D
	gms.	gms.	mgms	I.U.	mgs.	mgs.	mgs.	mgs.	I.U.
2400	75	1.0	15	5000	1.2	80	1.8	12	5000

The selection of food determines to a large extent whether or not the standards set up by the committee on Food and Nutrition will be met. The breakfast can supply an appreciable percentage of the daily allowance for specific nutrients as is shown in Tables II and III.

Table II

Specific Nutrients Which May be Obtained from a Sample Day's Dietary

Food *	Calories	Protein	Calcium	Iron	A	Thiamin	Ascorbic acid	Riboflavin	Nicotinic acid
		gms.	gms.	mgs.	I.U.	micrograms	mgs.	micrograms	mgs.
Breakfast									
Orange juice, whole milk, whole wheat bread, butter, cream, sugar	492.5	14.0	.137	1.89	472.5	411.2	62.0	330.5	7.02
Lunch									
Baked macaroni and cheese, tomato and lettuce salad with mayonnaise, whole wheat bread, butter, milk, apple	1140.0	28.12	.665	8.77	1627.23	315.0	54.15	389.5	.52
Dinner									
Roast beef, baked potato, buttered broccoli, carrot and raisin salad, vanilla ice cream and cocoanut macaroon	1111.8	45.8	.184	9.95	9765.5	446.5	187.75	1111.5	1.4
Tea with lemon and sugar									
	2744.3	87.92	.986	20.61	11865.23	1172.7	283.9	1831.5	8.92**

*Thompson, Goodrin, Table of proximate composition of some American foods, 1940, was used in calculating the specific nutrients.

**Because of inadequate data on the nicotinic acid content of food, this figure probably is low.

Table III

Requirement of Day's Nutrients
Supplied by a Sample Breakfast

Food Nutrient	Percent
Calories	20.5
Protein	18.7
Calcium	13.7
Iron	12.6
Vitamin A	9.4
Thiamin	34.2
Ascorbic Acid	77.5
Riboflavin	18.3
Nicotinic Acid	58.5

It must be kept in mind, however, that the average breakfast consists of a refined cereal with sugar, milk or a milk and cream mixture with coffee or coffee and a breakfast bread. Such a breakfast does not supply the vitamins and minerals in amounts comparable to those found in the sample breakfast in Table II. It does, however, supply a worthwhile source of calories which according to Haggard (1935) is important. His subject, whose muscular efficiency was being studied, was able to peddle a bicycle farther the first half

hour after the administration of cane sugar. Peddling tempo within the subsequent hours reached the before-breakfast level in somewhat over two hours after the sugar was given. Similar results were obtained for other carbohydrates.

Sugar is a universal ingredient of an American breakfast, as it is not only used in coffee, on cereals and fruits, but it is present also in numerous breadstuffs as rolls, doughnuts, etc. From Haggard's results (1935), any food taken containing concentrated carbohydrates will increase muscular efficiency for a time. From the standpoint of the total nutritional requirement of the individual, coffee and sweet rolls constitute a poorer breakfast than the one outlined in Table II. However, it still would make a contribution to the energy requirement of the individual.

2. Undernutrition and poor health habits as related to diet.

The effect of the quality of food in improving nutritional status of children was studied by Rosenberg (1931). Two groups of underweight children were used. The daily dietary of the experimental group consisted of one quart of certified milk, a variety of nuts, whole grain cereal products three times a day, fresh fruits and vegetables twice a day. Meats and eggs were excluded. The control group's daily dietary supplied one quart of grade A whole milk, ten percent of the total calories were obtained from protein with meat

and eggs served daily. Fruits and vegetables were served once a day. Most of the bread and cereals were not whole grain and no nuts were given. Rosenberg found that the experimental group gained 32 percent in height and 24 percent in weight over the control group. The general appearance and temperament of the children on the experimental diet was superior to that of the children on the control diet. The nitrogen retention was higher while the control group showed a lower nitrogen retention.

The experimental diet employed by Rosenberg was high in the vitamin B complex. Another type of dietary study has been made by McCormick (1940). The efficiency of his dietary was tested by the endurance of experimental subjects under conditions of specified work. Fourteen subjects held the arms horizontally as long as possible. Ten of the subjects had for some time prior to the test included in their diets a liberal intake of thiamin in the form of wheat germ, whole grain cereal and bran. The other four subjects used refined carbohydrates, white bread and devitaminized cereals. The endurance limit of the ten well-fed subjects ranged from 43 minutes to two hours; whereas that of the four subjects ranged from 13 minutes to 36 minutes. The four subjects were then given one five milligram tablet of thiamin daily for a week. The scores after vitamin therapy ranged from one hour, 13 minutes to two hours, 25 minutes. The enhanced physical performance under the

influence of thiamin, as shown in the arm holding test was thought to be due to the more rapid oxidation and disposal of the intermediary carbohydrate metabolites, lactic and pyruvic acids, produced in the sustained muscular effort. This work achievement evidently was affected by the catalytic action of the vitamin.

Friend (1936), after twenty years observation of boys at Christ Hospital, believes that the provision of a more perfectly balanced diet, at the same time taking into consideration the time allotted for meals, the spacing of meals and the time and opportunity for proper evacuation of the waste products of digestion would go far toward remedying much of the minor invalidism that at present handicaps and reduces the efficiency of the modern school child.

Emerson (1928), who collected data on the faulty health habits of 2,000 college women found that 90 percent or more of the cases of malnutrition or physical unfitness were due to (1) physical defects; (2) lack of home or personal control; (3) overfatigue; (4) faulty food habits and food intake; (5) faulty general health habits. He found that the higher the intellectual attainment, the poorer the health practices.

It was reported in a study on the health status of 4,366 Dartmouth freshmen and 1,106 Massachusetts Institute of Technology freshmen (Emerson, 1932) that 61 percent were in the zones of underweight and overweight in which the highest

mortality rates are found. Observation showed that most of the illnesses occurring during college life were in these two groups. Lessened efficiency was shown by the fact that the highest percentage of failures in preparatory school and college occurred in the seriously underweight and overweight groups. Since underweight and overweight are closely related to the quality and quantity of the diet, it can be assumed that at least half of the students in residence were consuming diets poor in one or more respects. In the cases of the underweights, diets probably were inadequate in amounts. One wonders what part irregularity in eating may have played.

It is accepted that most nutritional deficiencies result in a gradual decline of appetite. Thiamin has a greater effect upon the appetite as a physiological function than any other vitamin (Sherman, 1941). From this, one may surmise that in an individual whose thiamin intake is inadequate, the desire for food is lessened. Acute lack of appetite is apt to occur in the morning and breakfast may be omitted. It is unlikely that an individual will get the required amounts of specific nutrients in two meals, even though they are heavy. As a result, varying degrees of further undernutrition may develop. On the other hand, if three meals per day are eaten, one is more apt to meet the requirements for specific nutrients and at the same time maintain or improve nutritional status.

There has been little attempt to study the role of diet in influencing behavior. The relationship between diet and mental phenomena is known as psychodietetics and has been defined as "the science of the feeding of an individual in sickness and in health with particular reference to the mental aspect" (Fritz, 1933). McCollum (1932) believes that a very poor diet will dull the mental capacity of children and warp their personalities. This viewpoint is opposed by other writers (Dowd, 1922 and Rosenberg, 1931), who after experimenting with people of different age levels did not find results to substantiate McCollum's belief.

Conger's (1929) investigation showed that rats on a well-balanced diet voluntarily took more exercise than those on diets either lacking in animal protein or containing a very large amount. Low efficiency, reduced morale, loss of endurance, fatigability, tendency to forget, and loss of incentive among the people of Germany during the first World War were attributed by Mason (1920) to a low protein diet.

On the other hand, other authors varied in their opinions on the effect of protein in the diet as a factor in endurance. Berry (1909) favored the low protein diet, but Bassett and coworkers (1922) found no demonstrable effect upon physical capacity when meat was withheld for a period of one week. However, a meat-free diet is not necessarily a low protein diet.

3. Growth problems as they relate to dietary practices.

High school and college girls who omit meals or eat an insufficient amount of food in order to reduce may not only be forming poor health habits, but they may actually interfere with late growth. Barker and Stone (1936) reported that consecutive annual measurements made upon college women indicated that there was a small but significant increase in height throughout the four college years. This study has been confirmed by a similar study at Iowa State College* in which the younger women students showed an average increase of about one inch during the four years.

Growth in height, weight and retention of nitrogen, calcium and phosphorus during recovery from severe malnutrition have been studied by Stearns and Moore (1931) in a three and one-half year old child. Treatment was directed primarily toward improving the nutritional condition through a better diet. Gain in weight began before growth in height. The growth pattern exhibited by this child, that is, gain in weight, then increase in stature, may have an important bearing on understanding growth in older children.

4. The effect of irregularity of eating in limiting the intake of specific nutrients and on gastro-intestinal function.

*Unpublished data, this laboratory

It has been shown in Table II and III that the breakfast meal can furnish a worthwhile supply of specific nutrients, especially vitamins and minerals. Regular well-balanced meals also furnish an equal work load to the stomach and intestines without overworking any one function. Cannon (1936) stated that the stomach and intestines are devoted servants of the body; when well-supported and permitted to have their way, they do their work well. A poor appetite resulting in lowered food intake, is a common cause of constipation, especially in women, as an insufficient quantity of food frequently means inadequate bulk of waste material. In addition, an optimum quantity of food ingested regularly, directly stimulates the intestinal movements by virtue of its chemical and mechanical properties.

One of the main functions of the vitamin B complex is to promote gastro-intestinal motility and general bodily tone. Cowgill (1940), experimenting with dogs, observed a diminution of vigor in the normal contractions of the stomach as an early result of thiamin shortage. As the loss of normal motility may extend to the intestines, the frequently reported constipating effect of dietaries too largely composed of artificially refined foods may perhaps be due partly to insufficient thiamin intake (Sherman, 1941). Breakfast, with the opportunity it offers for the service of whole grain cereals, can contribute importantly to the thiamin intake.

Similar to the need for adequate consumption of vitamins, is the important role of minerals, especially calcium. Breakfast can offer an excellent supply of calcium in the form of wholesome beverages. Robertson (1937) reported that rats fed a diet low in minerals showed intestinal stasis, which was evidenced by dilation and overloading of the large intestines and by much delayed excretion of carmine and barium. When calcium was added to the diet deficient in this mineral, practically no stasis was found. Following the experiment on rats, a similar study was performed on 19 children fed diets low in calcium and potassium. Fourteen of them showed constipation. When given a barium meal, 35 percent of the 18 children fed diets low in calcium and potassium retained the barium for four to 21 days. The same children, when fed a normal diet, did not retain barium more than one day.

Vangart et al (1932), in a study of gastric acidity of 3,746 persons, in which careful examination did not reveal any disease which would conceivably affect the mucous membrane or the secretory activity of the stomach, reported that there was a steady increase in the incidence of achlorhydria from youth to old age. It is of interest to note that at all ages women showed a greater tendency to achlorhydria than did men. The question might be raised if the early and more frequent occurrence of true achlorhydria in women might possibly be related to the tendency to restriction and

irregularity of the food intake because of fashion.

Another aspect of the problem of spacing of meals is that of an economical use of one's digestive endowment. For instance, many investigators have observed that the ingestion of food is followed by a flow of bile into the intestines, although liver bile is constantly being formed. Bergh (1942) studied 34 patients who previously had undergone intubation of the common bile duct. The following test meals were given:

1. A fatty meal consisting of two raw egg yolks in a glass of cream flavored with sugar and 30 - 60 cc. of olive oil.
2. A protein meal consisting of two egg whites and two slices of lean trimmed beef.
3. A carbohydrate meal consisting of 200 cc. of sweetened fruit juice and two thin slices of unbuttered white bread spread thickly with fruit jam.

It was found that egg yolk and cream produced relaxation of the sphincter of Oddi with flow of bile into the intestinal tract. A protein meal occasionally produced relaxation and a carbohydrate meal had no significant effect upon the sphincter resistance. Nicheles and Kozell (1942) reported that the sphincter of Oddi is subject to psychic effects since the odor or sight of food produced tonus waves. Since the liver is constantly producing bile, the excess of which

is stored in the gall bladder and used as needed, and since much disease of the gall bladder apparently is associated with stasis of bile, regularity of food intake would seem important to promote regular emptying of the gall bladder. On the other hand, a breakfast consisting only of fruit juice, white bread and jam would offer little stimulus of the flow of bile.

5. Food intake as related to work efficiency.

Haggard's (1935) studies on the physiology of work show that a high muscular efficiency is the objective and measurable accompaniment of a subjective feeling of well-being and vigor. Ivy (1941) stated that when a person performs work in the ordinary sense, a constant ratio between energy expenditure and work output is not found even when the subject has been well trained. This is because the efficiency of muscular movements varies from time to time as well as from person to person. Accomplishment is affected by incentive, staleness, feeling tone and muscular efficiency.

The word "fatigue" as interpreted by Haggard and Greenberg (1935) is not fatigue as commonly conceived. A low output of an industrial product by factory operators during the last hour of the day's work might be attributed to fatigue in the sense of physical tiredness. However, in the case of operators who had eaten lunch but came to work without

breakfast, they found that the output in the fresh hours of the morning actually was lower than was observed in the afternoon following lunch. The state of mind, health and nutrition all influence performance (Ivy, 1941).

Haggard and coworker (1936) reported the results of a study on the effect of between meal feeding upon the rate of production among employees and factory workers. They observed an improvement of four percent in production and an eight percent decrease in errors in preparing monthly statements and checking charge slips, when food was given to the employees in the mid-morning and mid-afternoon. They noted a more cheerful and attentive attitude during the period when the supplementary feedings were given.

A similar type of study was reported in 1939 (Haggard and Greenberg) on observations among clerical employees. The majority of the employees favored the supplementary feedings and reported that they became less tired and were more cheerful and attentive to their work. Many subjects commented on the relief of constipation. There was a marked decrease in absenteeism among the employees receiving such feedings as compared to those receiving none.

On the other hand, Ivy (1941) suggested that impairment of production may be due to sociological and physiological factors which cannot be eliminated from any type of work. Was

Thus, with any type of muscular movement over a period of time, if there is an insufficient amount of oxygen coming to the tissues, the lactic acid formed from glycogen utilization in muscle contraction will accumulate. An excess of lactic acid inhibits muscle contraction. Hence, it is of importance that employees performing work, especially that of muscular movement, undergo medical examination. Such examination should include hemoglobin content of the blood, heart functions, and cardio vascular tests, as well as the routine tests for visual acuity, hearing, etc.

The use of age, height and weight as a basis of classification of physical fitness has been employed for some time. It, however, is not a perfect basis for classification of physical fitness or work performance. Age is an approximation of maturity. Normal weight does not necessarily denote strength, nor does it necessarily measure health. In spite of these limitations, height, weight and age are still useful for general classification of physical fitness.

An evaluation of strength as measured by grip (Whipple, 1914) or traction (Cooperative Regional Project Relating to the Nutritional Status of College Women, sponsored by certain Home Economics Sections of the Agricultural Experiment Stations of the North Central States, 1936) and endurance (McCormick, 1940) are desirable supplements to medical examinations. Since strength is the most important element in motor

the increased work output reported in the preceding studies due to improvement of nutrition or to the fact that the workers were given something?

B. Tests for Physical Efficiency

There are two major criteria for judging physical efficiency: (1) chemical tests, including medical examination and (2) the physical fitness index (McCloy, 1939).

The essential functions of nutrition, respiration, secretion and excretion are dependent upon the vascular system for the transportation of numerous substances. Health is dependent upon the maintenance of the blood flow which is governed partly by the condition of the heart, blood vessels, kidney and partly by the quality of the blood itself. Blood pressure and tests of cardio vascular efficiency are indices of the functioning of the circulation. In the normal individual the blood pressure is held very constant within a certain range and any persistent departure from this range is indicative of an abnormal situation which demands attention.

The red cell count also is of importance in the evaluation of health. Speaking generally, the function of the red cells is to carry oxygen from the lungs to the various tissues. This function is dependent upon the hemoglobin content of the individual cell as well as the number of cells.

performance (McCloy, 1939), it is felt that strength relative to age and weight is an excellent measure of an individual's ability to work.

C. Summary

In the foregoing pages, the desirability of an amount of food sufficient in both quantity and quality has been stressed. It is postulated that three or more well-balanced meals per day provides an avenue for obtaining optimum nutritional status. When considering work efficiency and its relation to food, the maximum work output is dependent not only on the kind of food eaten but upon the spacing of meals as well. Any habitual negligence in the choice of food or in the regulation of habits of eating may be primary factors in promoting undernutrition, the effects of which are reflected in gastrointestinal disturbances, improper growth and lowered efficiency.

It might be asked why the spacing of meals has not been taken into account more often in previous investigations. Haggard and Greenberg (1935) state that the answer lies in a peculiar technical feature of nutritional investigations on man. Investigators have assumed that precise conditions are afforded only by the basal state, thus in the pursuit of accuracy they often have lost touch with reality. The determination of efficiency before breakfast does not necessarily show the efficiency in the normal working period of the day, which is after

breakfast.

The factors of environment, health, social conditions, family, and other personal difficulties all bear upon the problem of diminished production (Ivy, 1941). There may be many causes of impairment of productivity, and no single remedy. Ill health, frustration by an unpleasant social situation and the frequency with which meals are taken all may influence production from hour to hour within the day (Haggard and Greenberg, 1935). However, since the food eaten is the primary source of energy and is the means by which the body performs external and internal work, it is of vital importance that the food be sufficient in quantity and quality and supplied at regular intervals in order to meet the normal body demands.

III. EXPERIMENTAL METHOD

A. Subjects

The subjects selected for this study were 25 upperclass college women, the majority of them obtained from classes in dietetics.

The following information was secured from each subject on the first test day:

1. Date of last menstruation
2. Breakfast eaten for three days prior to first test day
3. Average number of hours of sleep
4. Average number of cigarettes smoked per day
5. Record of recent illness
6. General food habits

The breakfast menu for that morning was recorded on each test day when breakfast was eaten. Even though the subjects resided in different houses, all breakfast menus included fruit, cereal and beverage, usually milk or cocoa.

B. Tests Employed for Determining Physical Efficiency

The tests chosen for this experiment were intended to

measure the following qualities: *

1. Muscle strength
2. Muscle coordination
3. Memory
4. Endurance

A variety of tests were used since it seemed probable that no one test would measure work efficiency as well as several tests. On the other hand, the number of tests which could be used was limited by time and available facilities. Since this is an almost unexplored field, there was little evidence available to indicate the usefulness of any single test in measuring work efficiency in this situation. The exact tests finally chosen to measure each of the above qualities was partly a matter of practicability.

1. Muscle strength

The grip tests used are described by Whipple (1914). This test was used as an index of general bodily strength. The grip of the right and left hands and traction were recorded.

A Narragansett hand dynamometer was used.

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*The writer takes pleasure in expressing her indebtedness to Dr. Thomas F. Vance, Professor of Psychology and Child Development, for recommending "Manual of Mental and Physical Tests" by Guy Montrose Whipple.

The test was conducted as follows:

The upward curved edge of the dynamometer was placed against the fingers and the more rounded edge against the base of the hand. The indicator was toward the palm and at zero before applying pressure. The outer edge of the dynamometer was held between the first and second joints of the fingers. The subject was allowed to assume any position she wished with the arm or body so long as the arm or hand did not rest against the body or any object. Each time the individual was encouraged to exert maximum effort. The record was read to the nearest pound.

The dynamometer in the accompanying case was used for the traction test. The subject, standing at ease, grasped the handles of the case of the dynamometer with both hands, bringing the instrument to the chest at the level of the middle of the sternum. The elbows were held at right angles to the body and pull was exerted with the forearms without allowing the instrument to touch the body. Each time the subject was encouraged to exert maximum effort. The record was read to the nearest pound.

In the event that the subject felt she could improve her records, a second opportunity was allowed for either hand grips or traction. The highest reading of the two trials was the one recorded. No more than two trials were allowed for any test due to fatigue of muscles.

2. Muscle coordination.

The idea of the test used for muscle coordination was obtained from Whipple (1914). The final selection of a cribbage board was determined by availability.

This test not only required work of the small muscles in the hands, it also required maximum attention for the best results. Reduction in attention was reflected in less speed or accuracy of work.

A standard 124 peg cribbage board was used. Pegs were made by removing the heads of three inch matches. Each match was shaped at the end in such a way that it fitted easily into the board. The cribbage board was placed on the table in front of the subject seated at ease in a straight back chair. She was instructed to use both hands to pick up the pegs and place them in the holes without purposely omitting any hole. If a hole were omitted, it could not be filled. Two minutes, timed with a stop watch, were allowed for each test. The total number of pegs placed, minus the holes missed was used as the test score.

3. Memory test.

The memory test used is described by Whipple (1914). This test is thought to measure visual perception under conditions of active attention. With repetition, however,

attention seems to diminish as memory becomes effective.

The following nonsense words were used:

F M R T U T H

W A E G Z S C

Six-inch letters were printed in black on white cardboard which was tacked to a lightweight wooden board. The board was held in front of the subject at approximately ten paces. Ten seconds, timed with a stop watch, were allowed to study the words after which time the letters in their remembered order were recorded by the subject. The guessing of a letter or letters was not encouraged. The total number of letters recorded in their correct places, minus the total number of errors measured as missing letters plus incorrect letters, was used as the test score.

4. Endurance.

The endurance test used is described by McCormick (1940). The muscles of the arms and shoulders were used. It is assumed that physical fitness of the subjects is determined by the ability to continue holding the arms horizontally since a rapid oxygen debt accumulates over a relatively short period of time.

The subjects were instructed to stand at ease with the arms horizontally extended as long as possible. Each subject was encouraged to hold the arms out to the point of maximum

endurance. Competition with previous scores of the subject or with scores of other subjects was encouraged. The time was recorded by a stop watch.

C. Experimental Plan

Each subject performed the entire series of tests during each test period. A total of four test days were used, on two of which breakfast was eaten and on two of which breakfast was not eaten. Two test periods per day were obtained; the first at nine o'clock, the second at ten or eleven o'clock. The time interval was determined by the availability of the subject. Three or four subjects were tested each day. In order to eliminate the effect of practice, each group of four subjects was alternated to conform as nearly as possible with the testing plan outlined in Table IV.

Table IV

Experimental Plan Followed in Arranging the Order of Testing Each Group of Four Subjects

Subject No.	First Test Day	Second Test Day	Third Test Day	Fourth Test Day
1	Breakfast	No breakfast	Breakfast	No breakfast
2	No breakfast	Breakfast	No breakfast	Breakfast
3	Breakfast	Breakfast	No breakfast	No breakfast
4	No breakfast	No breakfast	Breakfast	Breakfast

No tests were made during the menstrual period.

IV. DISCUSSION AND RESULTS

A. The Effect of Breakfast on Muscle Strength, Muscle Coordination, Memory and Endurance: General Averages

Tables V and VI include the summary of all observations in the series of tests performed by each subject in this experiment on days with and without breakfast. The detailed results of each test for each subject are recorded in Tables XIII and XIV in the appendix. The averages of all the tests on muscle strength, muscle coordination and memory showed little difference which could be attributed to the intake of food. However, the averages of all tests with the exception of grip in the left hand were higher when performed after breakfast, though none of the differences were significant. Muscle coordination was chosen for testing the significance of results of this series of tests on days with and without breakfast. The value obtained for F was below one, which, except that the degrees of freedom were very limited, would suggest that the test was not well adapted to distinguishing between the two experimental situations. Since the F value for this analysis was so low the results for the grip and memory tests were not studied statistically.

The author's impression was that the tests for memory

and for muscle coordination were too simple for college students, although they were recommended for use in similar test situations (Whipple, 1914). In fact, the students learned the nonsense words very rapidly, especially when testing was done on successive days. Each student had better than average manual facility, which perhaps was to be expected in a vocationally trained group, but which resulted in rapid and dexterous handling of the pegs on all mornings, irrespective of the food intake.

On the other hand, the average of tests for endurance showed a marked difference in favor of performance on days when breakfast was eaten. The difference was significant as is shown on Table VII ($F = 6.7$ with one and 24 degrees of freedom). This result would indicate that physical endurance is greater on mornings when breakfast is eaten than on mornings when breakfast is not eaten and also that the test was well chosen for measuring physical efficiency differences.

A check of individual records indicated that subject seven, previous to the experiment, habitually had omitted the breakfast meal. She was the only subject in the group who ate breakfast only on rare occasions. Since there might be a possibility of adaptation to working efficiently without breakfast, even though maximum efficiency for that subject was not obtained, averages for the entire series of tests with and without breakfast were calculated, eliminating subject seven. There were no differences in the average

Table V

Average of All Tests of All Subjects
with Breakfast *

Subject No.	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding Seconds
1	70.0	62.5	32.5	76.3	12.0	86
2	57.5	45.0	40.0	82.0	13.5	177
3	65.0	55.0	37.5	69.5	12.2	282
4	77.5	70.0	37.5	77.5	11.8	288
5	70.0	62.5	37.5	88.0	12.8	268
6	62.5	60.0	45.0	86.2	10.0	245
7	60.0	60.0	50.0	75.0	8.3	324
8	72.5	65.0	52.5	95.0	14.0	288
9	77.5	72.5	45.0	98.5	13.0	253
10	52.0	47.5	27.5	81.2	12.5	244
11	75.0	55.0	42.5	87.2	14.0	251
12	65.0	57.5	47.5	75.8	11.5	385
13	65.0	65.0	35.0	76.2	11.5	326
14	62.5	60.0	42.5	75.0	14.0	272
15	70.0	60.0	30.0	89.0	10.5	182
16	70.0	57.5	42.5	90.0	12.5	377
17	60.0	60.0	40.0	83.5	9.5	124
18	70.0	62.5	45.0	76.3	11.0	187
19	65.0	67.5	52.5	104.8	14.0	257
20	62.5	60.0	40.0	94.5	14.0	291
21	67.5	62.5	47.5	73.8	12.3	427
22	92.5	80.0	50.0	91.5	9.0	381
23	75.0	65.0	37.5	98.3	11.5	283
24	80.0	67.5	47.5	100.8	11.8	171
25	80.0	90.0	55.0	85.0	12.5	270
Average	68.8	62.9	42.6	84.1	12.1	233
Average without subject 7	71.4	63.0	42.3	84.7	12.6	229

*Two observations were made on each of two days on each subject.

Table VI

Average of All Tests of All Subjects
Without Breakfast *

Subject No.	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding Seconds
1	62.5	65.0	27.5	75.0	13.5	84
2	60.0	45.0	35.0	77.0	12.0	175
3	67.5	55.0	37.5	66.3	9.0	242
4	80.0	72.5	30.0	74.0	8.5	317
5	65.0	52.5	35.0	87.3	9.3	272
6	55.0	57.5	42.5	85.0	13.0	211
7	72.5	60.0	50.0	73.5	10.7	327
8	67.5	65.0	55.0	86.0	10.5	156
9	82.5	75.0	47.5	95.5	11.5	246
10	57.5	52.5	30.0	72.0	10.7	212
11	70.0	55.0	37.5	84.2	11.7	232
12	65.0	52.5	42.5	81.0	13.3	395
13	62.5	57.5	37.5	73.0	10.2	311
14	70.0	62.5	47.5	30.7	13.0	355
15	55.0	52.5	25.0	92.0	13.2	139
16	70.0	47.5	42.5	85.2	13.0	116
17	57.5	50.0	37.5	78.0	12.5	153
18	72.5	55.0	55.0	72.0	11.3	145
19	65.0	67.5	57.5	102.5	10.3	232
20	62.5	60.0	35.0	85.5	11.3	248
21	72.5	70.0	45.0	76.0	11.3	218
22	85.0	75.0	47.5	91.0	10.3	367
23	80.0	60.0	37.5	101.5	13.5	247
24	75.0	65.0	45.0	97.8	11.8	166
25	90.0	97.5	50.0	87.5	14.0	208
Average	67.7	63.4	41.8	83.6	11.9	183
Average without subject 7	67.5	63.6	41.4	84.1	11.7	177

*Two observations were made on each of two days on each subject.

Table VII

Analysis of Variance of Days With and Without Breakfast: Average of Muscle Coordination and Endurance

Source of Variance	Degrees of Freedom	Mean Square
	Muscle Coordination	
Total	49	
Between girls	24	100.30
Between diets	1	197.61
Error	24	282.17
$F = \frac{197.61}{282.17} = 0.703$		
	Endurance	
Total	49	
Between girls	24	9821.83
Between diets	1	17222. *
Error	24	2550.
$F = \frac{17222}{2550} = 6.75$		

A significant result is indicated by a single star (*)

figures without subject seven. (Tables V and VI).

B. The Effect of a One Hour Interval Between Tests on Mornings With and Without Breakfast

The first series of tests were given to the subject between nine and ten o'clock. The second series of tests followed one or two hours later, depending on the availability of the subjects. It was thought that a reduction in physical efficiency would be more marked as the fasting period was lengthened. Therefore, the test days on which one or two hour intervals occurred between observations were separated.

Table VIII shows the averages of the first and second test scores on mornings with two hour intervals between tests. Days with and without breakfast are given as in the previous tables. It was observed that there was little difference between the scores for the first and second tests on any given morning, except for endurance. Scores for endurance showed a difference in favor of the first test of the morning on days when breakfast was eaten and on days without food when the second test was made within an hour. The second test of the morning was, in each case, lower than the first. However, when the second test was not made until after eleven o'clock on mornings without breakfast, endurance scores were essentially

Table VIII

First and Second Test Scores With One Hour and Two Hour Intervals Between Tests on the Same Morning

Tests	With Breakfast: Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm holding Seconds	Without Breakfast: Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm holding Seconds
One Hour Intervals Between Tests												
1st	70.8	66.25	46.2	88.0	12.6	285	74.6	68.3	45.4	85.2	11.7	236
2nd	72.0	68.75	47.5	87.0	10.7	243	71.3	66.3	44.6	87.8	13.0	210
Average	71.4	67.5	46.8	87.5	11.6	264	72.9	67.3	45.0	86.5	12.3	223
Two Hour Intervals Between Tests												
1st	67.5	58.0	41.5	82.2	11.9	275	64.5	55.6	40.0	80.5	11.9	225
2nd	65.0	60.0	38.0	86.0	12.3	249	63.5	54.2	38.0	81.5	11.7	223
Average	66.3	59.0	39.8	84.1	12.3	262	64.0	54.8	39.0	81.0	11.8	224

the same as for the early morning test (225 and 223 respectively). Could this measure a tapping of the less labile nutritional reserves - a sort of second wind phenomenon?

When comparing the averages of the first test scores on days when breakfast was not eaten, with those on days when food was taken, it was observed that the average scores for right and left grip were essentially the same in each case. A possible explanation for the lack of a more negative effect when breakfast was omitted may be due to the fact that the subjects had not exercised sufficiently to be fatigued between nine and ten o'clock when these tests were performed. On the other hand, endurance which showed a decided difference in favor of breakfast in the first test of the morning may be a better measure of physical efficiency. There is further justification for this assumption in the fact that the score for the endurance test dropped in both cases at the ten o'clock reading. The grip tests required a sudden, brief expenditure of energy, while the arm holding test not only involved the performance of several movements, but extended over a period of time and brought into play the muscles of the shoulders and arms, as well as all of the muscles of equilibrium used in maintaining the upright position. This type of test apparently demonstrated the need of an adequate supply of energy for more efficient work performance because the effort expended was more complex and more prolonged.

Difference in scores of tests of strength, coordination and memory on days with and without breakfast were tested by analysis of variance. The results are shown in Table IX. No differences which could be attributed to breakfast were found between the test scores for right grip, traction, or coordination. Memory test scores were not treated statistically, since the test was not considered entirely adequate, as has been discussed. Diet influenced the test for left grip and endurance in that significantly higher scores were made on mornings on which food had been taken (Left grip, $F = 10.6$, degrees of freedom one and 11; endurance, $F = 14.8$, degrees of freedom one and 11). Since left grip was only one of a series of strength tests and the results in the others were not significantly different, it is doubtful if much importance can be attributed to this finding.

Again the lack of significant differences between dietary routines, except as were measured by the endurance test, may be due to the fact that no proven tests were available for a study of this sort and the results may measure lack of adaptability of the tests rather than real differences between test mornings. This is suggested by F values below one in several of the analyses, although here again definite conclusions cannot be drawn since numbers of observations were limited. However, in the observation of the students' reaction to each test, it was felt that the memory and coordination tests

Table IX

Analysis of Variance of Test Scores on Days With and Without Breakfast: Tests Within an Interval of One Hour

Source of Variance	Degrees of Freedom	Mean Squares
	Right Grip	
Total	23	
Between girls	11	176.98
Between diets	1	1.26
Error	11	20.58
$F = \frac{1.26}{20.58} = .061$		
	Left Grip	
Total	25	
Between girls	11	206.51
Between diets	1	59.74 **
Error	11	
$F = \frac{59.74}{5.64} = 10.6$		
	Traction	
Total	23	
Between girls	11	102.34
Between diets	1	2.34
Error	11	
$F = \frac{2.34}{10.29} = .227$		
	Muscle Coordination	
Total	23	
Between girls	11	239.86
Between diets	1	21.65
Error	11	10.95
$F = \frac{21.65}{10.95} = 1.96$		
	Endurance	
Total	23	
Between girls	11	12841
Between diets	1	14418 **
Error	11	972
$F = \frac{14418}{972} = 14.8$		

A highly significant result is indicated by a double star (**)

offered little challenge.

On the other hand, negative results may be due in part to factors not controlled in the experiment, such as:

1. The number and spacing of meals before the test day were not recorded.
2. Amount of sleep on the night before testing was not known.
3. The kind but not the amount of food eaten on the test morning was recorded.
4. Activity prior to and between tests was uncontrolled.
5. Emotional disturbances may have been present.
6. The number of cigarettes smoked per day was recorded but uncontrolled.
7. Tests were made at all phases of the menstrual cycle except the actual period.

Certain of these influences will be discussed later.

C. The Effect of a Two Hour Interval Between Tests on Mornings With and Without Breakfast

The trend of the differences between tests taken at two hour intervals on the same morning was similar to that found with a one hour interval (Table VIII). Other pertinent observations were made not apparent in the final scores. For instance, in the case of muscle coordination, all the errors

made in placing pegs occurred on mornings without breakfast at the eleven o'clock testing period. If tests involving prolonged competitive production had been available, it is possible that greater lowering of work efficiency would have been measured in the longer fast periods.

Differences in performance at two hour intervals of tests of strength, coordination and endurance on days with and without breakfast were tested by analysis of variance. The results (Table X) showed significant differences only in the test for right grip. The F value of the test for left grip is just below the five percent level. The other experimental differences were not significant even in the endurance test which in every case showed real differences in favor of mornings on which breakfast was eaten. A possible explanation for this result has been suggested.

D. The Effect of the Phases of the Menstrual Cycle on Muscle Strength, Muscle Coordination, Memory and Endurance on Days With and Without Breakfast

Hrdlička has stated that menstruation has an adverse effect on the muscle strength of women (Cooperative Regional Project Relating to the Nutritional Status of College Women, sponsored by certain Home Economics Sections of the Agricultural Experiment Stations of the North Central States, 1936). This study was not planned with the various phases of the

Table X

Analysis of Variance of Test Scores on Days With and Without Breakfast: Tests Taken Within An Interval of Two Hours

Source of Variance	Degrees of Freedom	Mean Squares
	Right Grip	
Total	19	
Between girls	9	57.95
Between diets	1	25.31 *
Error	9	7.95
$F = \frac{57.31}{7.95} = 7.95$		
	Left Grip	
Total	19	
Between girls	9	32.11
Between diets	1	90.31
Error	9	18.56
$F = \frac{90.31}{18.56} = 4.86$		
	Traction	
Total	19	
Between girls	9	123.09
Between diets	1	2.81
Error	9	6.98
$F = \frac{2.81}{6.98} = .402$		
	Muscle Coordination	
Total	19	
Between girls	9	248.95
Between diets	1	215.17
Error	9	99.11
$F = \frac{215.17}{99.11} = 2.14$		
	Endurance	
Total	19	
Between girls	9	8620.0
Between diets	1	3672.3
Error	9	3521.0
$F = \frac{3672.3}{3521.0} = 1.42$		

A significant result is indicated by a single star (*)

menstrual cycle in mind, except that no tests were made on the actual days of menstruation. However, a record of the date of onset of the last menstruation was kept and, in many students, dates of onset of two successive menstrual periods were recorded. The time between the day of onset of two successive periods was divided into three equal parts and the day's tests placed in the period representing the position in the menstrual cycle of that day. Table XI shows the average of the test scores of subjects with and without breakfast in the pre, post, and intermenstrual phases of the cycle. When the actual period of menstruation was omitted in testing, there seemed to be no effect of the menstrual cycle on physical performance. There was considerable variability between tests taken at any phase of the menstrual cycle. However, the variation was not consistent and, since no one girl was followed through all three periods of the cycle, a consistent effect perhaps was not to be expected.

E. Some Other Known Factors Which May Have Influenced Work Performance

Certain factors which might have affected performance have been listed on page 39. Although all of the factors listed were not controlled in the subjects studied, certain information gained from the students' records made possible the evaluation of the following in work performance: (1) use

Table XI

Performance of Subjects With and Without Breakfast
at Three Phases of the Menstrual Cycle

With Breakfast						Without Breakfast					
Pressure in Pounds			No. of pegs placed	No. of word letters recorded	Arm holding Seconds	Pressure in Pounds			No. of pegs placed	No. of word letters recorded	Arm holding Seconds
Right	Left	Traction				Right	Left	Traction			
Pre-Menstrual Period											
73.5	63.0	40.5	93.9	12.0	271	73.0	67.0	43.5	83.0	12.2	176
Post-Menstrual Period											
68.5	63.8	46.4	85.4	11.7	259	61.3	59.0	41.3	83.0	12.0	226
Inter-Menstrual Period											
67.3	58.2	40.4	81.6	12.3	230	69.3	60.4	40.8	82.6	11.6	215

of coffee as the breakfast beverage, (2) habitual smoking, (3) exercise, and (4) the kind of food eaten on mornings when breakfast was allowed.

Since the average breakfast frequently includes coffee and since the effect of the caffeine in coffee (Sollman, 1930) are "to produce a quicker and clearer flow of thought; disappearance of drowsiness and fatigue; a more sustained intellectual effort; a more efficient appreciation of sensory impressions and a more perfect association of ideas", it was impossible to ignore the possible effects of coffee on work performance. With this in mind, the dietaries of each subject were checked for the consistent use of coffee. There were five breakfast menus recorded for each subject tested - three before the testing series was begun and two on the mornings breakfast was eaten during the testing series. No student drank coffee regularly and the occasional cups recorded did not offer enough information for further examination. However, it seemed highly improbable that the irregular consumption of coffee observed had any effect on the experimental results.

Likewise, when considering an individual's output of work, it is a natural thought to take into consideration the amount and relationship of smoking to the output of work; therefore, the records were checked for the use of cigarettes. It was found that only four students were habitual smokers. Table XII compares the average test scores with and without breakfast of

Table XII

Average Test Scores With and Without Breakfast on Subjects Who Were Habitual Smokers

Subject No.	With Breakfast						Without Breakfast					
	Pressure in Pounds			No. of pegs placed	No. of word letters recorded	Arm holding Seconds	Pressure in Pounds			No. of pegs placed	No. of word letters recorded	Arm holding Seconds
	Right	Left	Traction				Right	Left	Traction			
1	57.5	45.0	40.0	82.0	13.5	177	60.0	45.0	35.0	77.0	12.0	175
2	60.0	60.0	50.0	75.0	8.3	324	72.5	60.0	50.0	75.0	11.0	327
3	70.0	60.0	35.0	89.0	10.5	182	55.0	52.5	25.0	92.0	13.3	139
4	70.0	57.5	42.5	90.0	12.5	200	70.0	41.5	42.0	85.3	13.0	116
Average	64.4	55.6	41.9	84.0	11.2	221	64.4	51.2	38.0	82.5	12.3	189
General average without above subjects	69.6	64.3	43.9	84.1	12.3	235	72.6	65.9	42.5	83.8	11.8	181

subjects who smoked regularly with those who smoked rarely or not at all. It was observed that left grip, traction and endurance scores made by the small groups of smokers were higher on mornings on which breakfast was eaten. It is also observed that the scores of the subjects who did not smoke were consistently higher in the grip and traction tests. The absence of appreciable differences between memory and coordination test scores made by subjects who smoked and those who did not smoke was not surprising, however, since both tests were recognized as inadequate for this situation. It was disappointing that the scores for endurance, which was considered the most effective test employed in this study, were higher for girls who smoked on days when breakfast was not eaten. However, since only four subjects were represented this easily could be attributed to sampling error. On the other hand, since the second series of tests were given at the eleven o'clock period for each of the four subjects who smoked, this might measure the mobilization of nutritional reserves to meet the demands of the longer fasting period.

Although the breakfast meal was not controlled on the mornings when food was allowed, a list of the food consumed was recorded in each case. All meals included fruit, cereal and a beverage, usually milk or cocoa so that breakfast menus were alike qualitatively. The amount of food eaten was not recorded. As a result, the differences entering into the

experiment are those of quantity rather than quality of food eaten. It is felt that the quantitative differences may be of little importance in this study because each student was tested within a relatively short time period and served as her own control.

Since all subjects were tested twice on each morning, activity prior to and between testing periods was considered. It was found that the intervals between tests were spent in laboratory and lecture classes and walking to and from the testing laboratory. No subject attended physical education classes or engaged in sports between tests. The activity prior to the first test was not known. However, students on this campus walk to school, for the most part, and a class before nine o'clock in the morning would be a lecture class, so little opportunity was offered for strenuous exercise periods. Hence, activity might be considered reasonably comparable for all subjects, though not controlled.

Another possible factor which might affect work performance is that of emotional disturbance. Such disturbances might be caused by disappointing news from home or an unpleasant encounter in school. No obvious emotional upset was encountered, though no attempt to pry into the students' personal life was made. It is not to be ignored that such disturbances might affect to a greater or lesser degree one's output of work.

F. Evaluation of the Problem

The results obtained from this experiment were disappointing. However, it must be remembered that devices for testing work efficiency under experimental conditions were not available. Measures of work output which have been made by others (Haggard and Greenberg, 1935; and Ivy, 1941) were conducted in factories where performance could be measured in terms of piece work. Muscle strength and endurance were the two tests in this study which gave significant differences in performance in relation to food intake. The grip test measured work performance for a short, intense period of muscular effort and observed differences were not uniformly significant. On the other hand, the test for endurance which required a more sustained muscular effort was more consistently influenced by diet. Moreover, this trained group of students had sufficiently good learning responses and enough manual dexterity that the tests chosen for memory and coordination did not impose a work strain. It is suggested that tests which require more strenuous physical exertion should be developed if further investigation of the problem is contemplated. Conclusions concerning the role of breakfast in work performance will have to wait for more intensive study.

Even though the results obtained in this study are more or less negative, one cannot assume that the place of

breakfast in the daily dietary is of no importance because, as was pointed out in the review of literature, breakfast can play a necessary part in providing sufficient amounts of all specific nutrients and in regulating the functions of the gastro-intestinal tract.

V. SUMMARY AND CONCLUSIONS

Twenty-five college women have been tested for work performance on mornings with and without breakfast. Tests for muscle strength, muscle coordination, memory and endurance were used.

The average of all the tests on muscle strength, muscle coordination and memory showed no difference which could be attributed to food intake. The averages of all the tests, with the exception of grip in the left hand, were higher, though not significantly so, when performed on days when breakfast was eaten. Endurance was significantly greater on mornings when breakfast was eaten.

Memory test scores were not treated statistically, as it was apparent before the study was completed that the test was not adequate for college students.

Diet influenced the tests for left grip and endurance significantly when tests were given at one hour intervals and influenced right grip significantly when tests were given at two hour intervals.

Work performance was not influenced by the phase of the menstrual cycle, although no tests were made during the actual period.

The average scores of subjects who smoked were lower in

every instance except for endurance tests made without breakfast, when compared with scores of those who did not.

It would appear that work performance during the morning hours, as measured in this study, is little affected by eating breakfast, except when the work was prolonged for several minutes, as was done in the endurance test.

If this problem is reinvestigated another time, the worker should develop tests which would require more prolonged physical effort than did those selected for use in this study.

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VII. ACKNOWLEDGMENTS

The writer wishes to express her sincere appreciation to the following persons who aided in this investigation:

Dr. Margaret A. Ohlson, Associate Professor of Food and Nutrition, for her untiring patience, encouragement and guidance throughout this study; and for suggesting the use of the cribbage board and pegs for testing muscle coordination and the arm holding test for endurance,

Miss Louise L'Engle, Assistant Professor of Food and Nutrition, for her interest in this study and for her willingness to interest her classes in Dietetics in this study,

The students without whose cooperation this study would not have been possible,

And Dr. P. Mabel Nelson, Head of Food and Nutrition Department, for her interest and encouragement.

APPENDIX

Table XIII

Original Measurements for Each Test for Each Subject with Breakfast: 25 Subjects

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding Seconds
1.	9:00	80*	70	40	78	10	83
		60	60	30	78	14	87
	10:00	70	60	30	73	10	87
		70	60	30	76	14	88
2.	9:00	60	50	40	80	14	185
		60	50	40	84	12	206
	11:00	60	40	40	82	14	159
		50	40	40	82	14	137
3.	9:00	70	60	40	70	7	317
		60	60	40	64	14	291
	11:00	70	50	40	70	14	243
		60	60	30	74	14	277
4.	9:00	70	70	30	86	9	285
		80	70	40	82	13	341
	10:00	80	70	40	80	11	260
		80	70	40	82	14	267
5.	9:00	70	60	50	86	12	276
		70	60	40	94	14	306
	11:00	60	60	30	80	12	272
		80	70	30	92	13	216
6.	9:00	60	50	40	88	7	300
		60	60	50	84	9	217
	10:00	50	60	40	85	10	266
		60	70	50	88	14	315
7.	10:00	60	60	50	71	4	399
		60	60	50	78	10	329
	11:00	60	50	50	70	5	327
		60	70	50	80	14	240
8.	9:00	80	60	50	92	14	307
		70	60	60	96	14	319
	11:00	70	70	40	92	14	321
		70	70	60	100	14	204
9.	10:00	70	70	40	90	11	272
		90	70	40	108	14	242
	11:00	70	80	40	96	14	282
		80	70	60	100	14	211

Table XIII (con'd)

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding Seconds
10.	9:00	60	40	30	68	11	274
		40	50	30	83	14	258
	11:00	60	50	30	84	11	255
		50	50	20	90	14	201
11.	9:00	70	50	40	80	14	279
		80	60	40	90	14	295
	11:00	80	60	50	84	14	169
		70	50	40	95	14	272
12.	9:00	70	60	50	73	7	505
		70	60	50	72	14	515
	11:00	60	50	40	82	11	240
		60	60	50	76	14	492
13.	9:00	70	60	40	78	7	342
		60	60	30	73	14	307
	11:00	70	80	40	76	11	296
		60	60	30	78	14	360
14.	9:00	60	60	40	66	14	292
		70	60	40	78	14	303
	11:00	70	60	50	72	14	283
		50	60	40	84	14	210
15.	9:00	80	70	40	80	3	115
		60	50	30	96	14	246
	11:00	70	60	40	86	11	127
		70	60	30	94	14	238
16.	9:00	80	50	50	87	10	360
		70	70	40	91	14	120
	11:00	60	50	50	92	11	174
		70	60	30	90	14	145
17.	9:00	60	60	40	72	5	121
		60	60	40	90	14	174
	11:00	60	60	40	80	8	90
		60	60	40	92	14	122
18.	9:00	70	60	50	68	10	262
		80	70	40	84	10	169
	10:00	70	60	50	66	10	174
		80	60	40	87	14	143
19.	9:00	70	60	60	101	14	284
		70	70	50	106	14	266
	10:00	60	70	50	104	14	250
		60	70	50	108	14	227

Table XIII (con'd)

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding
20.	10:00	60	60	60	90	14	317
		60	60	30	94	14	330
	11:00	70	60	40	98	14	195
		60	60	30	96	14	193
21.	9:00	80	60	60	72	9	214
		60	60	50	78	13	320
	10:00	70	70	40	66	14	166
		60	60	40	79	14	229
22.	9:00	100	70	60	82	8	390
		90	80	40	92	6	360
	10:00	90	80	50	94	16	372
		90	90	50	98	12	403
23.	9:00	70	70	40	94	6	323
		70	70	40	104	14	315
	11:00	80	60	40	96	12	310
		80	60	30	99	14	185
24.	9:00	80	70	40	93	10	175
		80	70	50	112	14	205
	10:00	80	70	50	92	9	124
		80	40	50	106	14	180
25.	9:00	70	80	50	84	10	300
		70	80	50	88	12	290
	11:00	90	100	60	82	14	271
		90	100	60	86	14	250

*Each series of tests for each hour represented a different day.

Table XIV

Original Measurements for Each Test for Each Subject Without Breakfast: 25 Subjects

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding: Seconds
1.	9:00	70*	60	40	72	12	87
		60	60	20	74	14	86
	10:00	60	70	30	76	14	81
		60	70	20	76	14	83
2.	9:00	60	50	30	75	6	159
		60	50	40	78	14	197
	10:00	60	50	40	78	14	197
		60	30	30	76	14	145
3.	9:00	70	60	40	64	3	256
		70	60	40	72	14	280
	10:00	60	40	30	59	5	180
		70	60	40	70	14	252
4.	9:00	80	80	30	70	2	341
		80	70	30	74	11	360
	11:00	80	70	30	70	8	248
		80	70	30	82	13	320
5.	9:00	60	60	30	82	7	302
		70	40	40	93	12	334
	11:00	60	50	40	84	6	246
		70	60	30	90	12	218
6.	10:00	50	50	40	76	10	202
		60	60	5	94	14	292
	11:00	50	60	40	80	14	191
		60	60	40	90	14	202
7.	10:00	80	60	80	76	6	319
		70	60	50	74	13	331
	11:00	70	60	50	74	10	335
		70	60	50	76	14	324
8.	9:00	70	70	60	80	4	--
		70	60	50	94	14	--
	11:00	70	70	60	82	10	282
		60	60	50	88	14	350
9.	10:00	90	80	40	84	7	244
		80	80	50	102	14	281
	11:00	80	70	50	94	11	219
		80	70	50	102	14	242

Table XIV (con'd)

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding: Seconds
10.	9:00	60	50	40	65	3	218
		50	50	30	78	14	256
	11:00	60	60	30	70	11	156
		60	50	20	78	14	222
11.	9:00	70	60	40	80	12	271
		70	50	40	87	14	231
	11:00	70	60	30	84	7	255
		70	50	40	86	14	211
12.	9:00	60	40	50	82	14	388
		70	60	40	84	14	384
	11:00	70	60	40	80	11	529
		60	50	40	78	14	350
13.	9:00	60	60	40	64	14	333
		70	60	40	72	14	322
	11:00	60	60	40	78	9	306
		60	50	30	78	14	283
14.	9:00	70	60	50	64	12	267
		70	60	40	54	14	272
	11:00	70	60	50	34	12	238
		70	70	50	81	14	250
15.	9:00	60	60	20	88	14	152
		50	50	30	98	14	171
	11:00	60	50	20	84	14	105
		50	50	30	98	14	128
16.	9:00	70	50	50	78	10	140
		70	50	40	89	14	144
	11:00	70	50	40	82	14	91
		70	40	40	92	14	85
17.	9:00	60	60	40	78	7	157
		60	50	30	80	12	140
	11:00	50	50	40	78	8	144
		60	40	40	76	14	128
18.	9:00	80	70	50	66	10	169
		70	50	60	74	10	127
	10:00	70	50	50	70	12	184
		70	50	60	78	13	100
19.	9:00	60	70	60	92	9	253
		60	70	60	106	14	223
	10:00	70	60	50	100	14	236
		70	70	60	112	14	236

Table XIV (con'd)

Subject	Time	Pressure in Pounds: Right	Left	Traction	No. of pegs placed	No. of word letters recorded	Arm Holding Seconds
20.	10:00	70	60	40	74	6	315
		60	60	30	82	14	202
	11:00	60	60	40	96	11	230
		60	60	30	90	14	243
21.	9:00	70	70	40	76	13	270
		80	70	50	80	14	215
	10:00	60	70	50	70	14	181
		80	70	40	78	14	205
22.	9:00	100	90	50	82	9	371
		80	70	50	98	11	346
	10:00	80	70	50	86	7	345
		80	70	40	98	14	261
23.	9:00	90	60	40	96	12	252
		80	60	40	104	14	262
	10:00	80	60	30	98	14	233
		70	60	40	108	14	240
24.	9:00	80	70	40	93	10	175
		70	60	50	98	14	240
	10:00	80	70	50	92	9	124
		70	60	40	108	14	124
25.	9:00	90	100	50	82	14	196
		90	100	40	90	14	237
	10:00	90	100	60	84	14	216
		90	90	50	94	14	181

*Each series of tests for the hour represented a different day.